CHAPTER 2
POPULATION RISKS FROM INDIRECT EXPOSURE PATHWAYS

This chapter describes the Agency's estimates of population risks due to indirect exposures to contaminants in cement kiln dust. In Section 2.1 EPA provides the background and starting point of this analysis, discussing what specifically is and is not included in the scope of the analysis and the resultant implications. Section 2.2 briefly lays out the conceptual framework of the risk scenario and assessment process, describing specifically the key sources and pathways of exposure and also receptors that are included in the assessment. Section 2.3 presents a summary of the approach used to estimate population risks. Section 2.4 presents a discussion of the results. Finally, Section 2.5 presents a discussion of the major limitations and Uncertainties associated with the indirect exposure analysis.

2.1 BACKGROUND AND SCOPE

The objective of this analysis is to characterize risks to populations that live near cement facilities and are potentially exposed via "indirect exposure pathways." As explained below, indirect exposures in this context can potentially occur when populations that live near cement facilities consume vegetables, beef and milk, and fish that have been contaminated by releases from the cement kiln dust waste management units (e.g., waste piles).

2.1.1 Starting Point of this Analysis

For this analysis the Agency used as a starting point the risk assessment data and results generated previously for the *Report to Congress on Cement Kiln Dust* (RTC) and *Notice of Availability on Cement Kiln Dust* (NODA). From this previous work, estimates of individual cancer risks and noncancer hazard indices were available for major pathways for which "indirect exposures" can occur for constituents released from CKD waste piles. The previous work was conducted in two stages, termed the original and expanded risk analyses.

Original Individual Risk Analysis

In its original analysis, the Agency conducted a quantitative assessment of the human health risks associated with the on-site disposal of CKD at five selected facilities. The methodology and results of this analysis are presented in the *Technical Background Document* for the RTC. The five facilities were selected to represent the two highest risk sites in each of the three pathways examined (ground water, surface water, and air) in a relative risk ranking of 15 case-study cement plants.

The quantitative analysis used EPA's MMSOILS, a screening-level contaminant release, fate, and transport model, to estimate ambient concentrations of constituents of concern in ground water, air, surface water, soils, and the foodchain. Details on the transport methodology used in MMSOILS for each specific medium can be found in *MMSOILS: Multimedia Contaminant Fate, Transport, and Exposure Model, Documentation and User's Manual (September 1992).*

The Agency used site-specific, regional, and national level data to characterize the five model facilities. These data represented the best readily available sources for simulating the environmental characteristics at each facility. The data did not represent the level of detail and accuracy needed to support a site-specific modeling assessment, but were consistent with the screening-level methodology used in the Agency's analysis.

The Agency's original analysis presents potential individual cancer risks and individual noncancer effects associated with on-site disposal of CKD at the five modeled facilities through the ground water, air, surface water, soil, and foodchain exposure pathways. The analysis presents both "best estimate" and "upper bound" exposure concentrations at each facility based on best estimate and more conservative values for key environmental transport parameters contributing most to ambient concentration estimates.

In order to examine the upper range of the national risk distribution from the on-site management of CKD, the Agency also conducted a sensitivity analysis of six higher risk scenarios that combined the five sets of actual facility characteristics with selected potentially high risk practices or settings observed by EPA. Each of these scenarios was constructed from the baseline case study facilities and only a few key factors not attributable to the facility were modified to simulate the potentially higher risk factor. The six higher risk scenarios were (1) disposal of CKD with the highest levels of 2,3,7,8-substituted dibenzo-p-dioxins (CDDs) and dibenzo-furans (CDFs) measured by EPA; (2) disposal of CKD with the upper 95th percentile measured constituent metals concentrations, based on combined EPA and industry samples from nearly 100 CKD facilities; (3) simulation of a CKD pile located directly adjacent to an agricultural field with uncontrolled erosion of CKD to the crops; (4) simulation of a CKD pile located directly adjacent to a surface water body with uncontrolled CKD erosion directly to the water; (5) simulation of CKD management in the bottom of a quarry that is covered with water from ground-water seepage; and (6) simulation of exposures related to subsistence level food consumption by farmers and fishers. The results of these sensitivity analyses are also presented in the *Technical Background Document* for the RTC.

Expanded Individual Risk Analysis

EPA conducted further analysis of potential human health and environmental damages associated with the on-site management of CKD in order to expand the scope of its original analysis, and to respond in part to public comments received on the RTC. The methodology and results of this expanded analysis are presented in the *Technical Background Document* for the NODA. In its expanded analysis, the Agency estimated order of magnitude risks not likely to be exceeded at an expanded sample of 82 cement plants.[1] First, the Agency evaluated CKD generation and management practices at each facility to determine the potential for contaminant migration and exposure via environmental media. Where a release was found to be possible, the Agency evaluated environmental factors to determine the potential for releases to specific environmental pathways. Facilities with negligible risks for all pathways because of CKD generation and onsite management

[1] At the time of the original analyses, EPA evaluated risks at 83 facilities from a total of 115 cement plants nation-wide. Since then, to reflect more current data on cement production in the U.S., EPA has revised the total number of cement manufacturing facilities in the U.S. to be 108. Of this 108 cement plants, 82 are a part of the original risk analyses conducted for the RTC and NODA.

practices were eliminated from further analyses. For facilities not screened out, the Agency estimated the risks associated with each pathway by matching the facility to one of the five originally modeled cement plants to which it was most similar. The Agency then qualitatively and quantitatively related the original modeled risk estimates to risks associated with the facility being examined. By mapping each of the expanded sample facilities to one of the five facilities modeled in the RTC, the Agency estimated a rough level of risk for the facilities.

To relate the potential risks of the expanded list of sample facilities to the risks of one of the five modeled facilities, the Agency first identified the RTC modeling scenario, either one of the five baseline onsite CKD management scenarios (best estimate or upper bound) or one of the sensitivity analyses of higher risk scenarios, that most closely resembled the conditions at each of the sample facilities. This selection of a "best match" facility was accomplished by comparing the sample facility to the various RTC modeling scenarios along the dimensions of certain risk-driving variables, such as the size of the CKD management unit, the extent of contaminant features, the distances to water bodies and potential receptors, and parameters that affect the mobility and dilution of chemicals in the environment (e.g., stream flow and wind speed). As a result of this step, the Agency identified the RTC modeled facility that was a best match to the sample facility as well as a linear scaling factor that could be used to quantitatively adjust the risk estimates for the best match RTC modeling scenario to estimate risk at the sample facility, accounting for differences in key parameters at the two sites. The second step compared the selected RTC modeling scenario and the sample facility strictly in terms of relative chemical concentrations in CKD. The chemicals contributing most to cancer and noncancer risk estimates for the selected RTC scenario were identified, and for those chemicals, a ratio of the concentration modeled in the best match RTC facility to the concentrations measured in CKD from the sample facility was developed. This chemical concentration ratio was then used with the scaling factor based on other risk-driving parameters to adjust the selected RTC results to estimate risk at the sample facility.

2.1.2 What is Included and Excluded from the Scope of this Analysis

This analysis includes assessing risks to populations due to indirect exposures. In general, indirect exposures can occur when contaminants are transferred from primary contaminated media to secondary exposure media or pathways with which receptors (or populations of interest) come in contact. For example, contaminants released to air may pose risks not only via inhalation (direct exposure), but also via surface water, soil, and other media that become contaminated through deposition (indirect exposure). Atmospheric deposition can also lead to uptake of toxic contaminants into aquatic and terrestrial food webs. For example, herbivores can ingest contaminants deposited onto plants; these contaminants may biomagnify at higher trophic levels leading to significant human exposures via the food chain. For the purposes of this analysis EPA uses the term "indirect exposure" to describe the scenario when populations around cement facilities are exposed via ingestion of vegetables, beef and milk, and fish that have accumulated contaminants originating from the cement kiln dust being managed at the facilities. Exposures via such food-chain pathways can be considered indirect exposures because the CKD contaminants are transported by one or more transfer media before residing in the contaminated media with which the receptors come in contact.

More direct exposure pathways (such as direct inhalation of contaminants in the air, and dermal contact with and/or ingestion of contaminated ground water, surface water, and soil) were excluded from this portion of the analysis because they are addressed elsewhere (e.g., in looking at impacts on populations due to airborne particulate matter from CKD piles) or were deemed to be less significant, relative to the indirect pathways, in terms of population risks.

This analysis includes assessing risks primarily to potential receptors who live within an "area of influence" that is defined by a five-mile radius around each cement facility. Populations beyond this area are excluded from the analysis because the Agency assumes that they are not affected significantly, relative to populations within the radius, by ingestion of contaminated foods that originate from within the area of influence. That is, this analysis assumes that vegetables and beef and milk "grown" in the area are not exported and they do not lead to exposures in areas remote from the facility. Exposures due to ingestion of contaminated fish are not limited to the "area of influence," however, since fishermen from anywhere can be exposed if they fish in the contaminated streams near the facility. (Note that excluding populations beyond the area of influence is an issue only for estimating the <u>noncancer</u> population effects; given the linear, non-threshold calculation procedures estimation of the magnitude of population <u>cancer</u> risks is <u>not</u> dependent on where the exposed populations are located. For comparison, EPA also assessed the feasibility of using an alternative approach to calculate population risks that was not restricted to populations within the area of influence; this alternative approach and associated limitations are discussed in Section 2.5.2)

This analysis includes assessing risks directly at 82 of the total 108 cement facilities. The remaining 26 facilities are excluded because a lack of relevant data prevented them from being assessed directly. To account for potential risks at these excluded facilities, however, results from the 82 facilities were extrapolated to the 26 facilities to derive a composite picture of potential risks at the full universe of cement facilities.

2.2 SUMMARY OF POPULATION RISK ASSESSMENT FRAMEWORK

2.2.1 The Risk Scenario Being Assessed

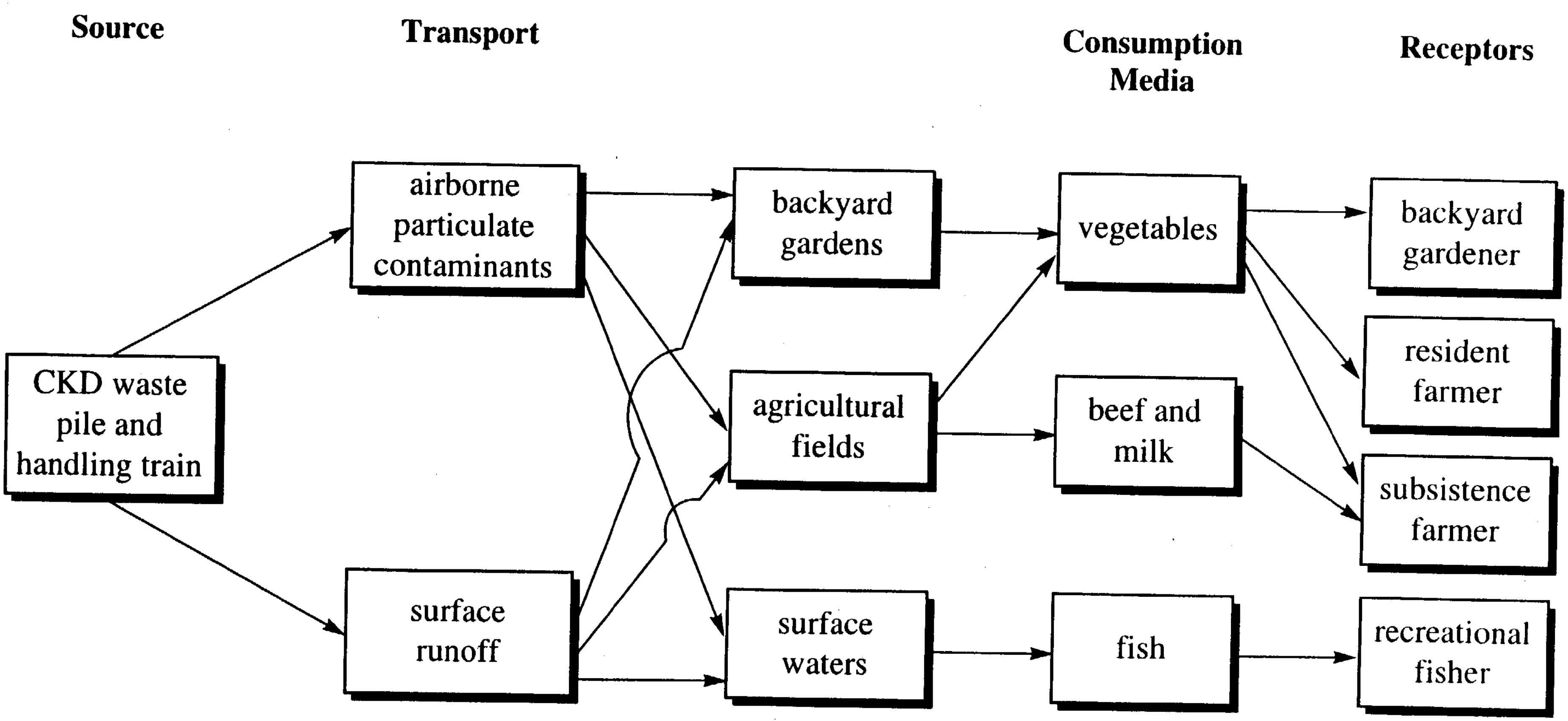
The "risk scenario" assessed by the Agency for this population risk analysis is summarized in Exhibit 2.1.

As shown for a given facility, **releases** of contaminants occur from the CKD waste pile, which is the **source** of contamination, due to wind-blown erosion of particulate matter and surface runoff of dissolved and particulate matter due to precipitation.

The contaminants are then **transported** via (i) atmospheric dispersion and deposition and (ii) overland runoff onto backyard vegetable gardens, agricultural fields, and rivers/streams in the close vicinity of the facility.

Backyard vegetable gardens, agricultural fields, and rivers/streams in the vicinity become the sources of the final **contaminated media** with which **receptors** come into contact. At the backyard vegetable gardens and agricultural fields, the contaminants accumulate in the roots and leafy parts of vegetables and in grass. For agricultural fields they also accumulate in the tissue and milk of cattle

Exhibit 2-1
Risk Scenario



that feed on the contaminated grass and vegetables and incidentally ingest soil. Contaminants that reach the rivers/streams accumulate up the foodchain eventually reaching the tissue of fish.

Several different types of **receptors** are potentially exposed to these contaminated media. Two different groups of receptors or "populations of interest" were considered relevant in terms of ingestion of contaminated vegetables and contaminated beef and milk.

(i) **"Homegrown" population (i.e., "resident farmers" and "backyard gardeners") within five miles of the facility**. The term "resident farmers" refers to individuals or families living on farms that have annual sales of $10,000 or more. These individuals get some portion (i.e., assumed 25%) of their vegetable <u>and</u> beef and milk diet from their farm. The term "backyard gardeners" refers to individuals with vegetable gardens at their place of residence. These individuals are essentially part of the non-urban population that does not live on farms (i.e., part of the non-urban, non-resident farmer population). These individuals get some portion (i.e., assumed 25%) of their vegetable diet from their garden.[2] For the vegetable ingestion pathway, both of these groups are assumed to be exposed to the same levels of contamination (i.e., ingest the same amount, and therefore have the same level of individual risk), and therefore, are treated as a single population of interest, referred to as the "homegrown" population. *Note that risks to resident farmers due to ingestion of contaminated beef and milk are assessed separately from risks due to ingestion of vegetables.*

(ii) **"Subsistence farmers" within five miles of the facility**. The term "subsistence farmers" refers to individuals or families with farms that have annual sales of less than $10,000. These individuals are assumed to get a somewhat larger portion (i.e., 40%) of their vegetable <u>and</u> beef and milk diet from their farm.[3] *Note that risks to subsistence farmers due to ingestion of contaminated beef and milk and to ingestion of vegetables are derived as a single numeric estimate.* Individuals or families that have annual farm sales of $10,000 or less are expected to earn $2,000 to $2,500 in actual income per year from the sale of agricultural products. Assuming that this cannot be the only source of income for these individuals or families, it is reasonable to infer that some, or perhaps most, of the individuals/families with farm sales of $10,000 or less use farming to supplement their income and most likely their diets. Thus, they are more likely to eat a larger portion of "homegrown" vegetables and beef and milk than farmers on large, commercial farms. (One limitation of this method is that some farmers who report earning $10,000 or

---

[2] The "fraction of food from contaminated source" is taken from the assumptions used in the RTC and NODA analyses (see also Appendix A). The original reference for the values used for this exposure parameter is USEPA 1989 *Exposure Factors Handbook.* Office of Health and Environmental Assessment. EPA/600/8-89/043.

[3] Ibid.

less from farm sales may not actually be growing vegetables, but instead, may be raising livestock or renting out their farms for that income.) **Note:** In consultation with county agricultural extension agents, sources in academia, and contacts at the Census of Agriculture, EPA determined that a reasonable method for estimating the number of **subsistence farms** was to use a proxy for subsistence farms based on readily available farm economics data. Our method assumes that farms that earn less than $10,000 per year from the sale of their farm products are subsistence farms. Data on the number of farms with earnings less than $10,000 per year are available in the 1992 Census of Agriculture.

Only one "population of interest," the **recreational fishers,**[4] was considered for ingestion of contaminated fish. For the purposes of this analysis, EPA assumed that fish (generally, Trophic Level 3 and 4 fish) from the rivers/streams in the area of influence are caught and consumed by fishers at "recreational fisher" levels. That is, the daily fish ingestion rate used in calculating the population of interest is that for a typical recreational fisher.

For the RTC and NODA, exposures to contaminated vegetables were estimated for the agricultural field closest to the cement plant. (The level of contamination in this field was predicted through fate and transport modeling of the air deposition and overland runoff pathways, not accounting for any situations in which CKD was applied directly to fields as a substitute for agricultural lime.) Thus, the individual risk was calculated for a hypothetical person ingesting contaminated vegetables "originating" from this field. In using this individual risk to estimate population risk in the current analysis, EPA made the conservative assumption that the levels of contamination in vegetables from any agricultural field or backyard garden within five miles of the facility are the same as those in the vegetables from the closest agricultural field (i.e., the field used in modeling the individual risks). Likewise, for the RTC and NODA, exposures to contaminated fish were estimated for the "fishable" water body that was closest to the cement plant and could potentially be contaminated. The level of contamination in this water body was predicted through fate and transport modeling of the following pathways: air deposition, overland runoff, and where applicable, ground water discharge to surface water. The individual risk was calculated for a hypothetical person assumed to be ingesting contaminated fish caught from this water body. In using the previously calculated individual risks to estimate population risk for the current analysis, EPA assumed that (i) contaminants can reach all rivers, streams, lakes, etc. located within five miles of the facility (the "area of influence"); (ii) all relevant water bodies in the area of influence are contaminated to the same level as that estimated for the closest water body; and (iii) all large streams and their tributaries can support fish populations that can be caught and eaten by recreational fishers in the area of influence. The Agency did not include very small streams or intermittent streams in this analysis because it is unlikely that they can support significant fish populations.

---

[4] Another population of potential interest is **subsistence fishers**; this category includes populations with fish consumption rates at the subsistence level. This population was not included in the current analysis because of the greater uncertainty, in the absence of detailed site-specific surveys, that would be inherent in developing site-specific estimates of subsistence fishers populations.

2.2.2 The General Approach for Assessing the Risk Scenario

This analysis was conducted in accordance with EPA's existing guidance on risk characterization and exposure assessment. Guidance on risk characterization was provided by EPA's Risk Assessment Council in a February 26, 1992 memorandum entitled *Guidance on Risk Characterization for Risk Managers and Risk Assessors*, and more recently by the EPA Administrator in a memorandum dated March 21, 1995 entitled *Policy for Risk Characterization at the U.S. EPA*. The Agency also relied on direction provided by EPA's most recent guidelines for exposure assessment, i.e., *Guidelines for Exposure Assessment; Notice*, Federal Register 22888, May 29, 1992. One key principle provided by these guidance documents is that consistent risk descriptors (i.e., consistent across Agency programs) should be used to represent the range of different exposure conditions encountered (e.g., central tendency and high-end individual risk, risk to highly-exposed or sensitive subpopulations, population risk).

The general approach for assessing the risk scenario consists of two main components: characterizing individual risks and characterizing population risks. All the "standard" steps of the risk assessment framework, i.e., the hazard identification, dose-response assessment, exposure assessment, and risk characterization, were conducted for the first component originally as part of developing estimates of individual risk for the RTC and NODA. (The exposure assessment step in this earlier work included estimating intakes for the exposed individuals based on pathway-specific contact rates and exposure assumptions; these are summarized in Appendix A of this document.)

Note that no new estimates of individual risk were developed for the current analysis; all population risk estimates were derived based on previously developed individual risk estimates.

The population risk characterization component builds upon the exposure assessment and risk characterization steps noted above. For exposure assessment, the additional step involved developing estimates of the number of people living near cement facilities who potentially are exposed via the indirect exposure pathways (e.g., resident farmers, recreational fishers). For risk characterization, the additional steps involved first selecting the appropriate population risk descriptors, then selecting the appropriate individual risk estimates to represent exposure and risk levels in the populations, and, finally, estimating the number of people living near cement facilities who potentially will exhibit a cancer or noncancer effect due to exposure.

Based on the EPA guidance documents, and given the information on individual risk already available in the RTC and NODA, the Agency used the following risk descriptors to characterize population risks.

- **Population cancer risk**. This descriptor corresponds to the "probabilistic number of health effect cases" noted in the guidance. The Agency estimated population cancer risk, or the "excess cancer incidence" in the exposed population, by multiplying the individual cancer risk (i.e., average lifetime excess cancer risk for an individual) by the size of the exposed population of interest. The product was the number of excess cancer cases expected in that population over a specified period of time.

- **Population noncancer effects.** This descriptor corresponds to the "number of persons above... or within a specified range of some reference level" noted in the guidance. To estimate population noncancer effects, EPA used the individual hazard index (HI) calculated previously to represent the individual HI to all individuals in the population of interest. Thus, if the individual HI exceeded 1, indicating that the individual's estimated exposure exceeded the reference dose (RfD), EPA counted every member of the population of interest as having an HI greater than 1.

Note: For simplicity, EPA uses in this document the terminology "population cancer risk" and "population noncancer effects," which is in accordance with existing EPA guidance, in particular the March 21, 1995 memorandum from the EPA Administrator entitled *Policy for Risk Characterization at the U.S. EPA*. Throughout the remainder of this document EPA uses three specific terms: (i) "population cancer risk" to denote "excess cancer incidence," i.e., the number of excess cancer cases in the exposed population (while an estimate of individual cancer risk cannot be greater than 1, because it refers to a probability, an estimate of population cancer risk can be equal to any number, because it refers to the number of cases); (ii) "population noncancer effects" to denote the number of persons exposed to levels above the thresholds for noncancer effects; and (iii) "population risk" as a loose, collective term to refer to both population cancer risk and population noncancer effects (recognizing that noncaner effects are not equivalent to risks, per se).

Also in accordance with the guidance, EPA used the mean or central tendency estimates of excess individual cancer risk or noncancer HI for the extrapolation to population-level risk estimates. Because the variation in risk within the "populations of interest" is unknown, it was most appropriate to use central tendency individual risk estimates for the population cancer risk and population noncancer effects calculations. In short, the high-end individual cancer risk and HI estimates, by definition, are likely to apply only to a small fraction of the population, so use of these descriptors would likely result in substantial overstatement of the population risk. Thus, the Agency used the following data from the RTC and NODA for the population risk analysis:

- Individual risk estimates based on modeling using the median (50th percentile) constituent concentration (rather than the 95th percentile concentration).

- Individual risk estimates that were denoted as "best estimate" (rather than those denoted as "upper bound").

In some cases, there was a range of risk estimates presented in the RTC or NODA, often with only the upper end of the range noted. Even though the ranges do not indicate the most likely central tendency estimate, EPA chose (as a conservative approach) to use the upper end value of any range that was presented without a central tendency estimate.

2.3 SUMMARY OF OVERALL APPROACH

In sum, the overall approach for this analysis was to combine the facility-specific individual risk estimates with facility-specific data on populations potentially exposed via the indirect pathways to derive facility-specific population risks. Then, the facility-specific population risks were aggregated to describe population risk across the full universe of CKD facilities. The Agency used a two-tiered approach (followed by a final refinement step for the "homegrown" and subsistence farmer populations) to systematically screen for those facilities that contribute significantly to population risks and to iteratively derive refined estimates of the populations exposed.

2.3.1 Tier 1: Screening Analysis

The Tier 1 analysis was identical for the vegetable ingestion, beef and milk ingestion, and fish ingestion pathways. In Tier 1 EPA conducted a screening analysis to derive population risk estimates using the following readily available data: (i) the individual risk estimates that had been derived for the RTC or NODA for 82 facilities, and (ii) a conservative assumption that, at each facility, 100% of the surrounding population within five miles is exposed to levels predicted for the individual risk estimates (i.e., all the "populations of interest" defined above were set as equal to the entire population within five miles of the facility). The individual risk estimates for the relevant pathways and facilities, derived for the RTC or NODA, are summarized in Appendix B of this document.

2.3.2 Tier 2: Detailed Analysis

The results from Tier 1 screening of the beef and milk ingestion pathway, for resident farmers, indicate that no facilities are of concern for further analysis for this pathway. Thus, based on the results of Tier 1, the Tier 2 analysis was conducted for only the fish ingestion pathway – recreational fisher population, vegetable ingestion pathway – "homegrown" population, and the vegetable and beef and milk ingestion pathway – subsistence farmer population. The focus of Tier 2, the detailed analysis, was to develop more refined, facility-specific estimates of the number of people who are potentially exposed for the facilities identified as being of concern in Tier 1. That is, in Tier 2 EPA developed more accurate estimates of the "populations of interest" that were then used to recalculate the population risks. For more details on the data used to derive the populations of interest, refer to Appendices D and E of this document.

"Homegrown" and Subsistence Farmer Populations

The step-wise approach for developing the facility-specific estimates of the two "populations of interest" for the vegetable and beef and milk ingestion pathway is described below, with calculations for **Facility #60** shown as an illustrative example. (Note that the assumptions and sources of data cited for Facility #60 are the same as those used for all the other facilities.)

Step 1. Estimate the <u>total</u> number of farmers within a five-mile radius of the facility

$\frac{\text{land area within the five-mile radius}}{\text{land area within the county}}$	*	total farm population in the county	=	the number of farmers within five miles of the facility

- land area within the five-mile radius = 78.5 mi^2

- total area within the county for Facility #60 = 568.4 mi^2
(source: the USA Counties - (State) Home Page, accessed via the 1992 Census of Agriculture)

- total farm population within the county for Facility #60 = 2,114 people
(source: the 1990 Census of Population and Housing)

$$\boxed{\frac{78.5 * 2{,}114}{568.4} = 292 \text{ farmers}}$$

Step 2. Estimate the number of <u>subsistence</u> farmers within a five-mile radius of the facility

number of farmers within five miles of the facility (from Step 1)	*	<u>number of "subsistence farms" in the county</u> total number of farms in the county	=	the number of subsistence farmers within five miles of the facility

- number of farmers within five miles of Facility #60 = 292
(from Step 1)

- number of "subsistence farms" in the county for Facility #60 = 123

- total number of farms in the county for Facility #60 = 821
(source: the 1992 Census of Agriculture)

$$\boxed{\frac{292 * 123}{821} = 44 \text{ subsistence farmers}}$$

Step 3. Estimate the number of <u>backyard gardeners</u> within five miles of the facility

Step 3(a)

total population within five miles of the facility	*	<u>total urban population within the county</u> total population within the county	=	urban population within five miles of the facility

- population within five miles of Facility #60 = 29,085

- total <u>urban</u> population within the county for Facility #60 = 37,181
(source: the 1990 Census of Population and Housing)

- total population within the county for Facility #60 = 46,733
(source: the 1990 Census of Population and Housing)

$$\frac{29{,}085 * 37{,}181}{46{,}733} = 23{,}140 \text{ urban people}$$

Step 3(b)

total population within five miles of the facility	–	urban population within five miles of the facility (from Step 3(a))	=	non-urban population within five miles of the facility

- total population within five miles of Facility #60 = 29,085
- urban population within five miles of Facility #60 = 23,140 (from Step 3(a))

29,085 – 23,140 = 5,945 people (non-urban) within five miles of the facility

Step 3(c)

non-urban population within five miles of the facility (from Step 3(b))	–	number of farmers within five miles of the facility	=	non-urban, non-farm population within five miles of the facility (i.e., potential backyard gardeners)

- non-urban population within five miles of Facility #60 = 5,945 (from Step 3(b))
- farmers within five miles of Facility #60 = 292 (from Step 1)

5,945 – 292 = 5,653 potential backyard gardeners

- The number of **backyard gardeners** calculated in Step 3(c) refers to those individuals who, because they are non-urban, could potentially have backyard gardens. EPA's *Exposure Factors Handbook* (August 1996 SAB Review Draft, Office of Research and Development, EPA/600/P-95/002Ba) notes that, based on 1986 data from the National Gardening Association, 38 percent of U.S. households participated in home vegetable gardening. The Agency contacted the National Gardening Association and updated this information: based on 1995 data, 45 percent of U.S. households that can be classified as "rural" participated in home vegetable gardening. Thus, for this analysis, EPA assumed that 45 percent of the 5,653 potential backyard gardeners are more likely to be exposed via contaminated vegetables from home gardens. Data from the National Gardening Association also indicated that, on average, 22 percent of U.S. households that can be classified as "non-rural" (i.e., city, small town, and suburban) participated in home vegetable gardening. Thus, in addition to 45 percent of the potential non-urban backyard gardeners, we assumed that 22 percent of the 23,140 urban people are likely to be exposed via the contaminated vegetables from home gardens.

Step 4. Derive the two "populations of interest" within five miles of the facility

(i) "Homegrown" population

total farmers (from Step 1) - subsistence farmers (from Step 2) = resident farmers	+	potential backyard gardeners * percentage of rural U.S. households participating in vegetable gardening = backyard gardeners more likely to have actual home gardens	+	urban population * percentage of non-rural U.S. households participating in vegetable gardening = urban population likely to have home gardens	=	"homegrown vegetable" population within five miles of the facility

(292 - 44) + (5,653*0.45) + (23,140*0.22) = 7,833 people potentially exposed via "homegrown vegetables" for Facility #60

(ii) "Subsistence farmers"

Subsistence farmers within five miles of the facility (from Step 2) = 44 people

Recreational Fisher Population

The general approach for determining the population of interest for the fish ingestion pathway is to determine the number of recreational fishers that can be supported by the "standing stock" (i.e., the fish yields) of the water bodies in the area of influence based on county-specific steam data, fish exploitation rates, and ingestion rates. The step-wise approach for developing the facility-specific estimates of the population of interest is demonstrated below, with Facility #62 as an example.

Step 1. Calculate the stream acres within a five-mile radius of the facility

stream length within the five-mile radius	*	average stream width	*	640 acres/mi^2	=	stream acres within five miles of the facility

- stream length within the five-mile radius = (a) tributaries of streams/rivers: 24.5 miles (b) streams/rivers: 9 miles (determined from USGS topographic maps)

- stream width = (a) tributaries: 1/350 mile (b) major rivers: 1/70 mile (determined from USGS topographic maps)

(a) 24.5 miles	*	1/350 miles	*	640 acres/mi^2	=	44.8 stream acres
(b) 9 miles	*	1/70 miles	*	640 acres/mi^2	=	82.3 stream acres

44.8	+	82.3	=	127.1 stream acres within five miles of the facility

Step 2. Estimate the pounds of fish caught (i.e.,"harvested") per year within the area of influence

standing stock (lbs/acre/yr)	*	stream acres within the five-mile radius	*	exploitation rate	=	pounds of fish caught per year in the area of influence

- standing stock = 89.5 lbs/acre/year (determined from aggregate fish biomass data obtained from the local department of natural resources. For this facility, fish biomass data were averaged for two sampling sites located within five miles of this the facility).

- stream acres = 127.1 (from step 1)

- exploitation rate (i.e., percent of standing stock caught by fishers) = 20% (default value, suggested for use in EPA's *Hazard Ranking System* (HRS) Final Rule, *Federal Register* Vol. 55, No. 241, December 14, 1990)

89.5 lbs/acre/yr	*	127.1 acres	*	20%	=	2,275.1 lbs fish caught per year in the area of influence

Step 3. Estimate the number of recreational fishers that can be supported by the harvest

lbs of fish caught per year (lbs/yr)	*	percent of fish tissue that is edible	÷	lbs of fish ingested per year by a recreational fisher	=	number of recreational fishers that can be supported by the harvest

- lbs fish caught per year = 2,275.1 lbs/yr
  (from step 2)

- percent of fish tissue (by weight) that is edible = 35%
  (default value, derived based on conversations with local fisheries authorities and data provided in EPA's *Exposure Factors Handbook*, (August 1996 SAB Review Draft, Office of Research and Development, EPA/600/P-95/002Ba)

- lbs fish ingested per year by a recreational fisher = 5.86
  (derived based on the daily fish ingestion rate used in originally calculating individual risks from food chain exposure in the RTC/NODA)

2,275.1 lbs/yr	*	35%	÷	5.86 lbs/year/person	=	136 people

There are several additional site-specific assumptions that EPA employed in determining fish yields; these are described below.

Facility #35

For this facility, there was only one major river flowing within five miles of the facility. All other streams were intermittent; these can not support fish populations, and, thus, were not included in this analysis. Other water bodies within the area, such as lakes and reservoirs, were not included.

Facility #37

The land area surrounding this facility is primarily swamp which is known to support fish populations. From conversations with local authorities, EPA determined that fish population studies have not been conducted for this swamp area. Thus, the Agency was restricted to applying standing stock data from a river within the county where the facility is located to the area covered by swamp.